

IT TAKES WORLDWIDE CONTINGENCY PLAN
BUILDING AUTOMATION WHATEVER IT TAKES
WHATEVER IT TAKES FACILITY OPERATIONS



TECHNICAL SUPPORT WHATEVER IT TAKES
WHATEVER IT TAKES SECURITY SOLUTIONS
DISASTER RESPONSE
JOHNSON
CONTROLS
ENERGY EFFICIENCY

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JCI Federal Business Goal

- ***"Help the Army Accomplish its Mission Critical Goals"***
 - Energy security
 - ❖ Constant power
 - ❖ Secure facilities
 - ❖ Reduce energy usage
 - Base sustainability
 - ❖ Water resources
 - ❖ Infrastructure revitalization
 - BRAC 2005
 - ❖ Keep SWRO installations open
 - ❖ Master planning
 - ❖ Added value to the bases
 - Reduce capital budget burden



Army Systems and Services

- Energy Savings Performance Contracting
- Security Systems
- Fire Systems
- Construction Management
- Mechanical Equipment and BAS Service Contracts
- Facility Management
- Building Automation Systems



ESPC Overview

- ESPC Vehicles
 - Corps of Engineers
 - Department of Energy
 - GSA
 - MEDCOM
- ESPC Energy Conservation Measure Examples
 - Energy Security
 - Lighting
 - Water
 - Re-commissioning
 - Infrastructure improvements
 - Peak shaving
 - Building Automation Systems - Digital controls

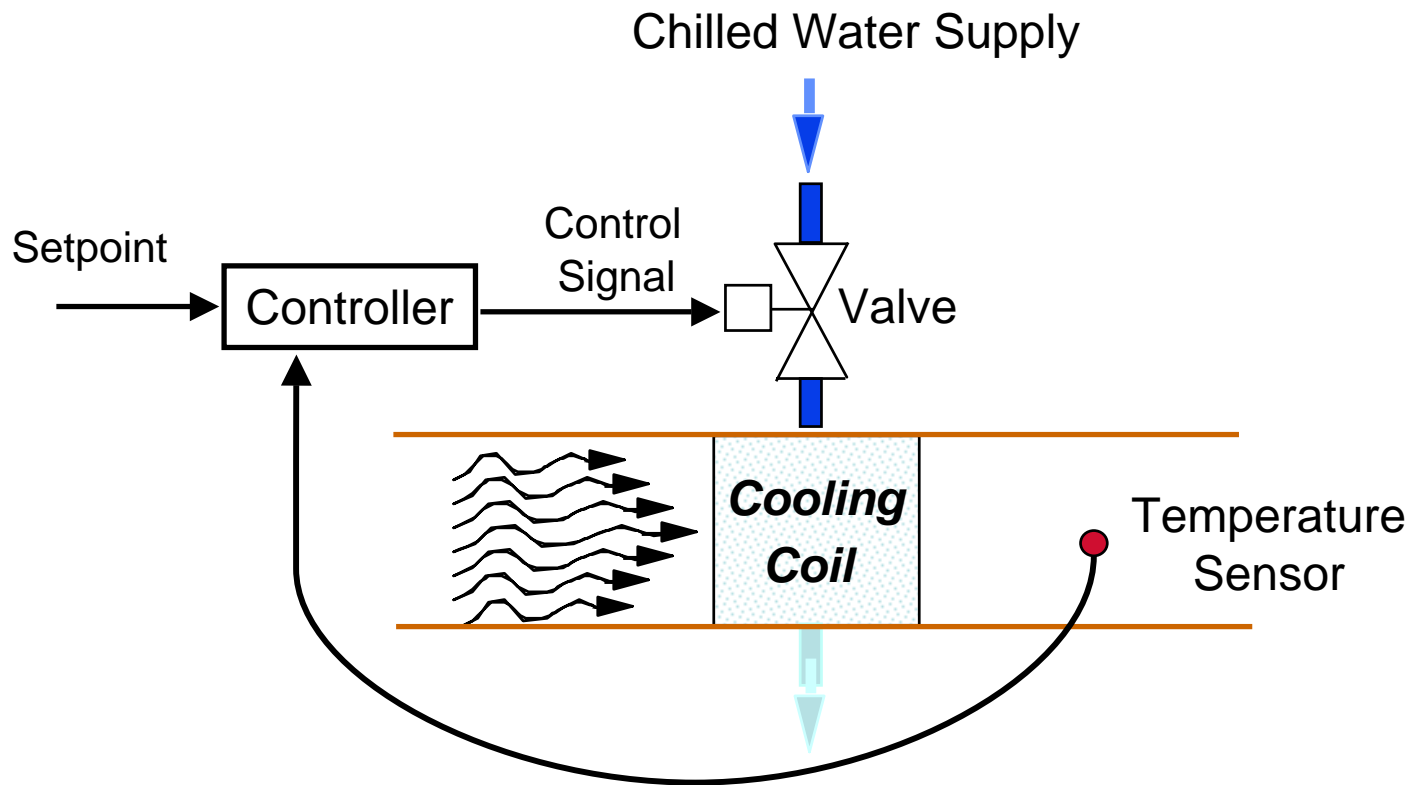
New Energy Saving Strategies for HVAC Control Systems

John E. Seem, Ph.D.

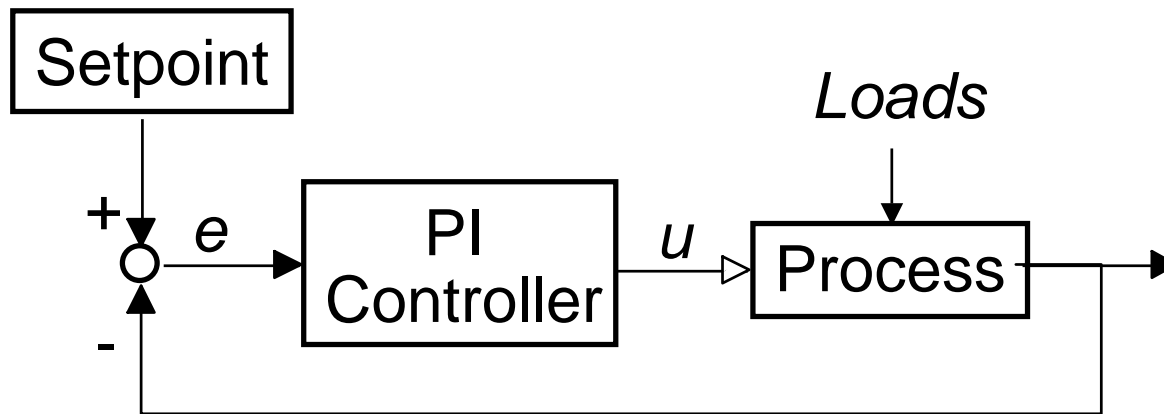
Agenda

- Adaptive Feedback Control
- Fault Detection & Diagnostics
- Sequencing Control
- Energy Optimization Control

Feedback Control System



PI Controller



Gain

$$u(t) = \bar{u} + K \left[e(t) + \frac{1}{\tau_I} \int_0^t e(t^*) dt^* \right]$$

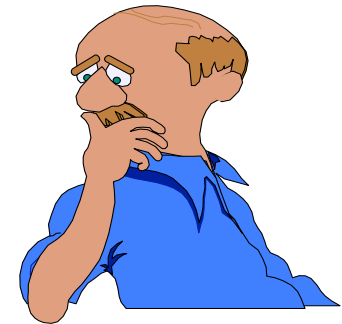
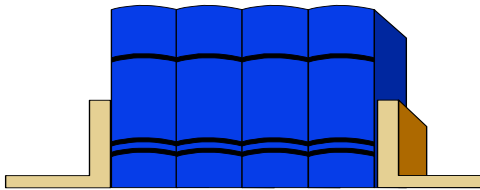
Integral Time

Problem

Although PID Controllers are common and well known, they are often *poorly tuned*.

Åström and Hagglund (1988)
Automatic Tuning of PID Controllers

Adaptive Feedback Control



- + Thousands of Papers
- Hard to Develop Industrial Controller

Approaches

- Self-Tuning Control
- Model Reference Adaptive Control
- Pattern Recognition Adaptive Control

Research Objective: Adaptive Feedback Control

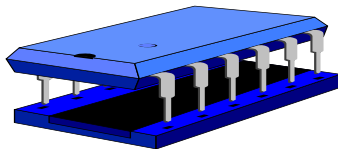
Develop Continuous Tuning Method for PI Controllers

Features

- Easy to Use
- Near-Optimal Performance (IAE)
 - Load Disturbances
 - Setpoint Changes

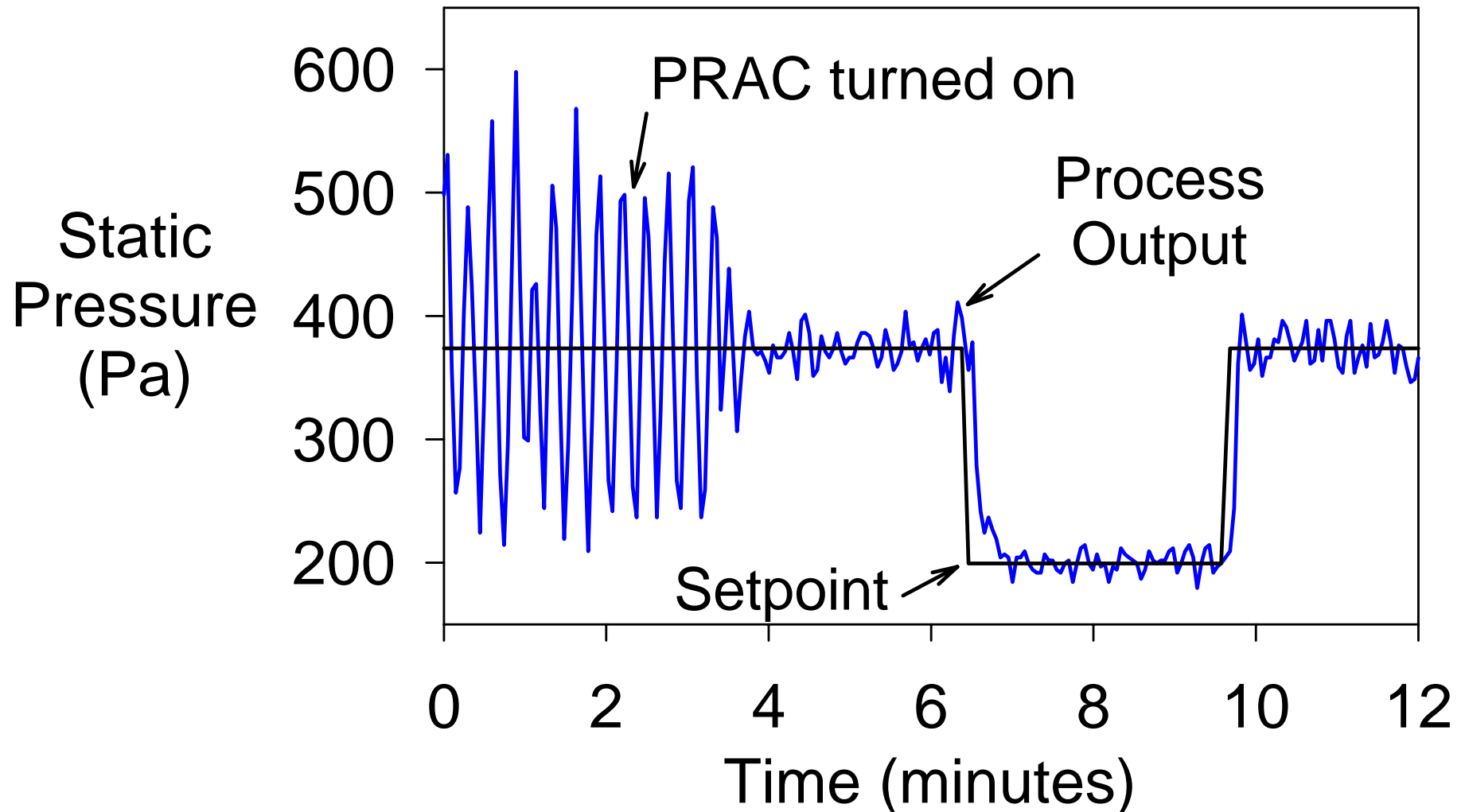
- Robust

- Low

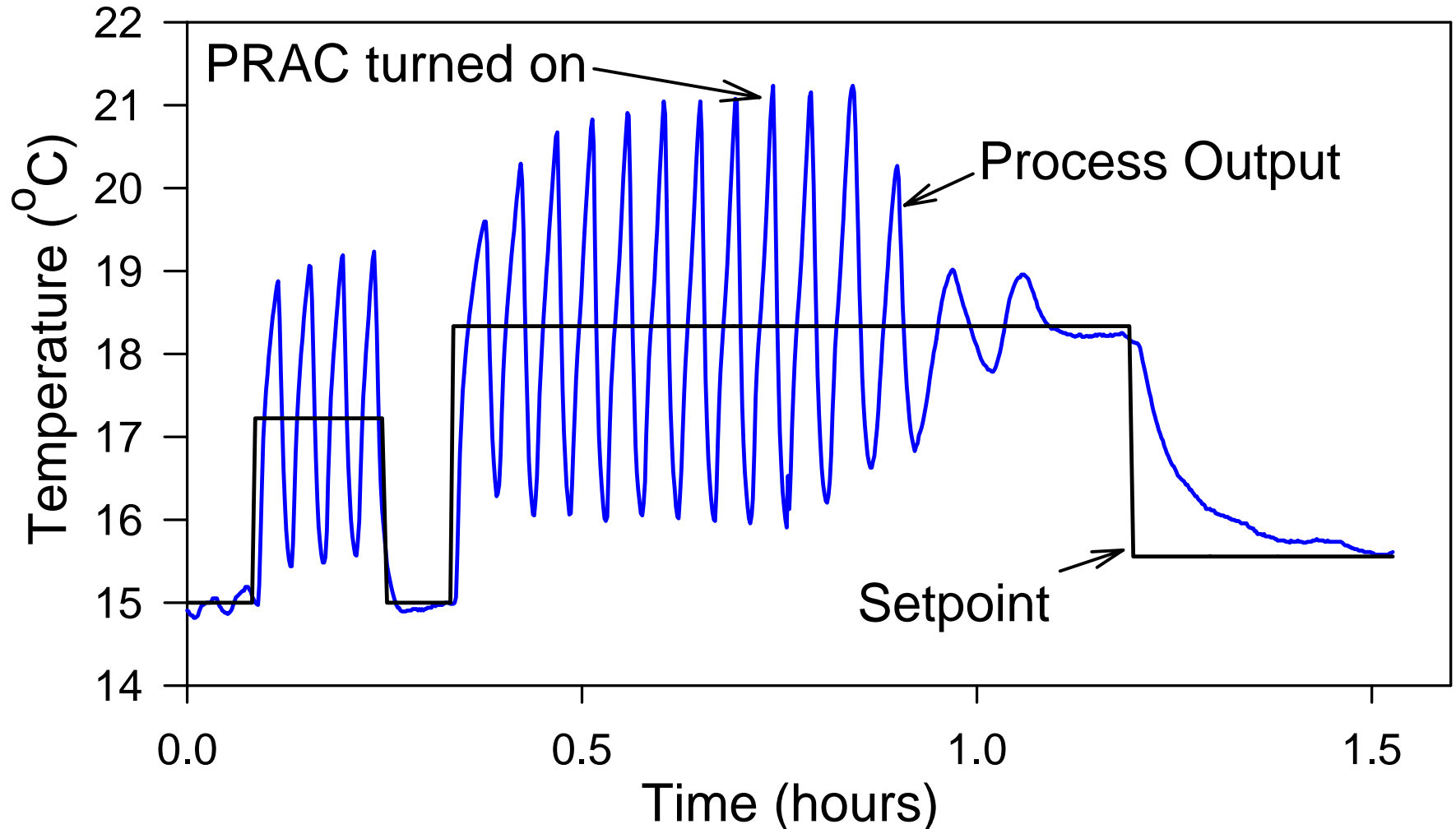


Requirements

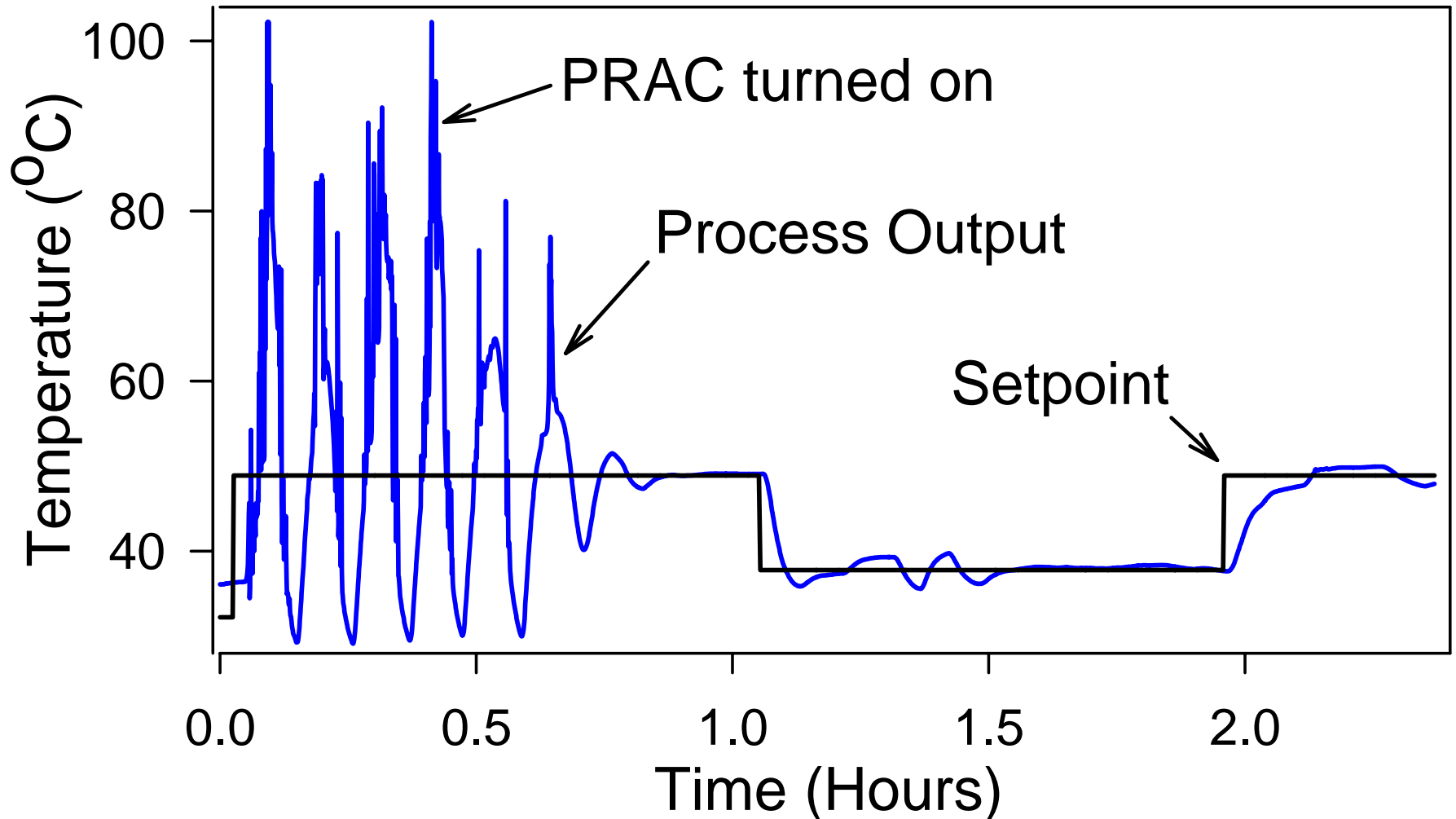
Field Test: Static Pressure



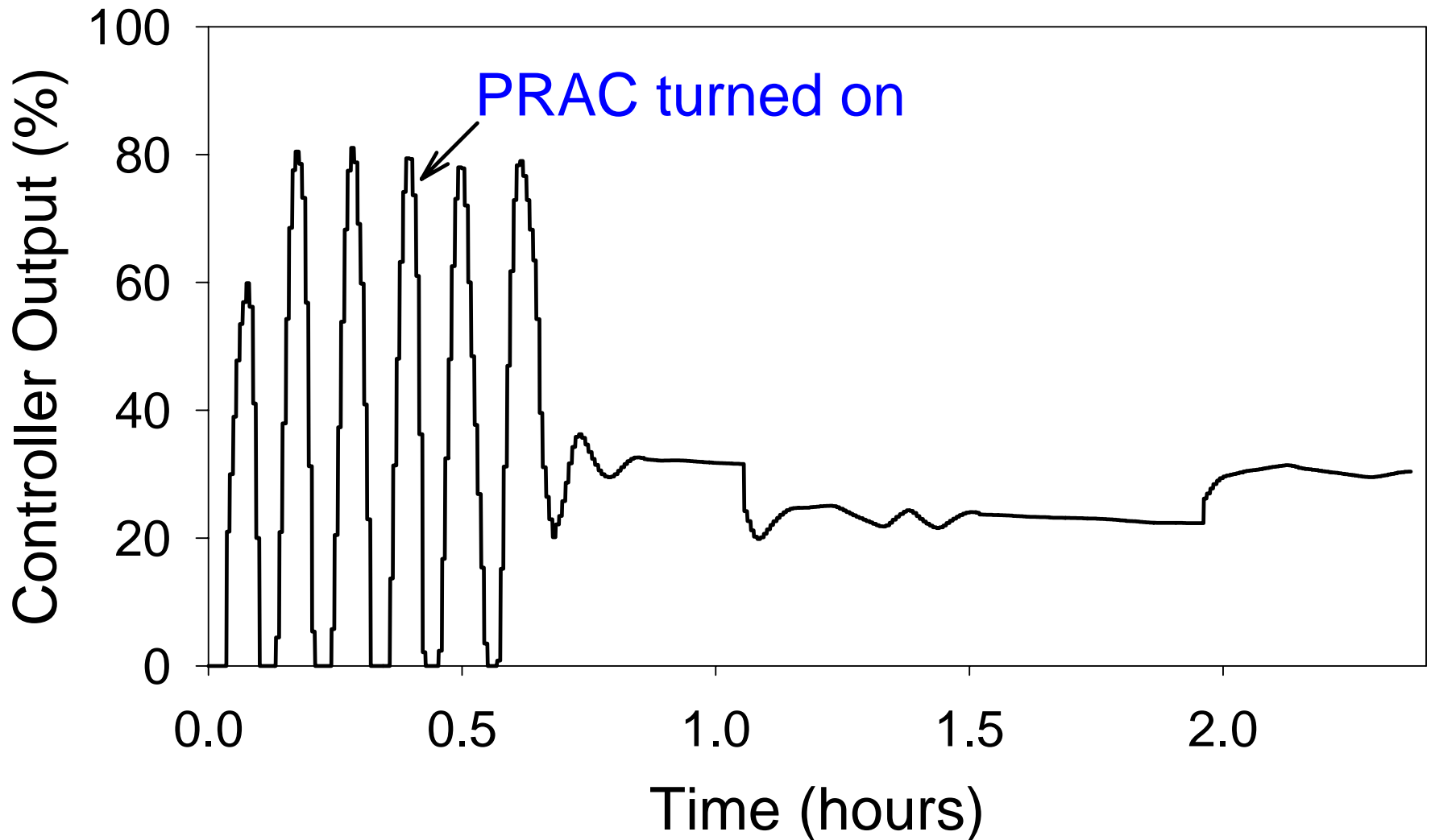
Field Test: Cooling Coil



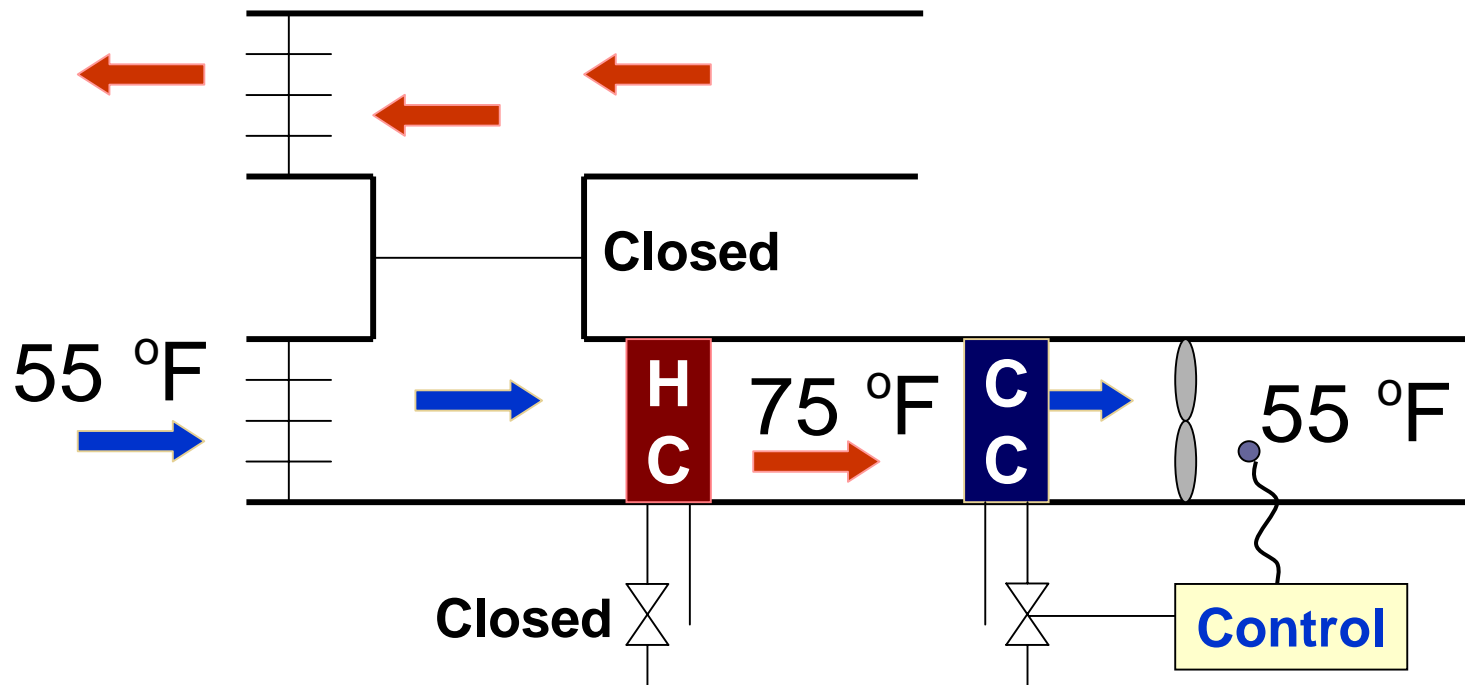
Field Test: Heating Coil



Field Test: Heating Coil



AHU Fault Detection

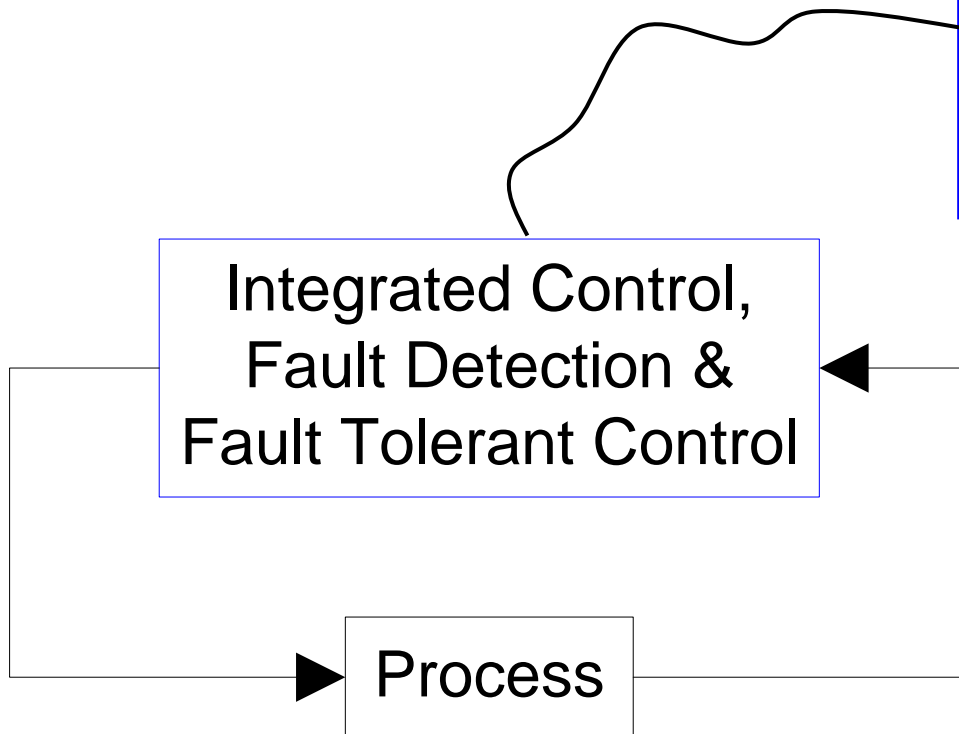


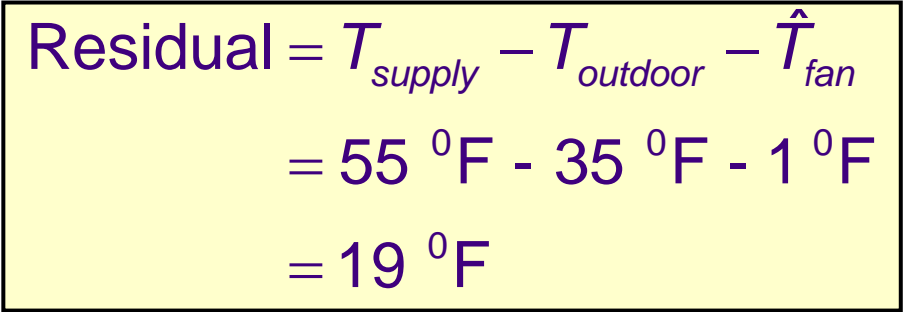
Research Objective

- Detect leaky valves, stuck dampers, ...
- No additional sensors

Approach for AHU Fault Detection

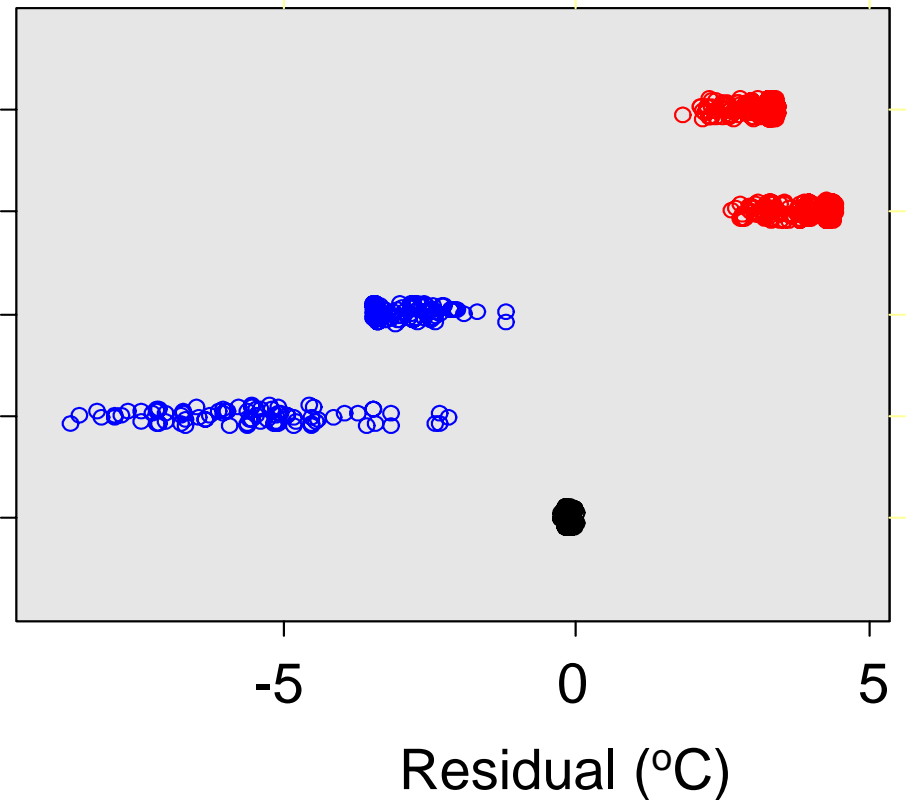
- 1) State Machine
 - Mode of Operation
 - Steady-State Conditions
- 2) Model Based Residuals
 - Mass Balances
 - Energy Balances
- 3) Control Performance Indices



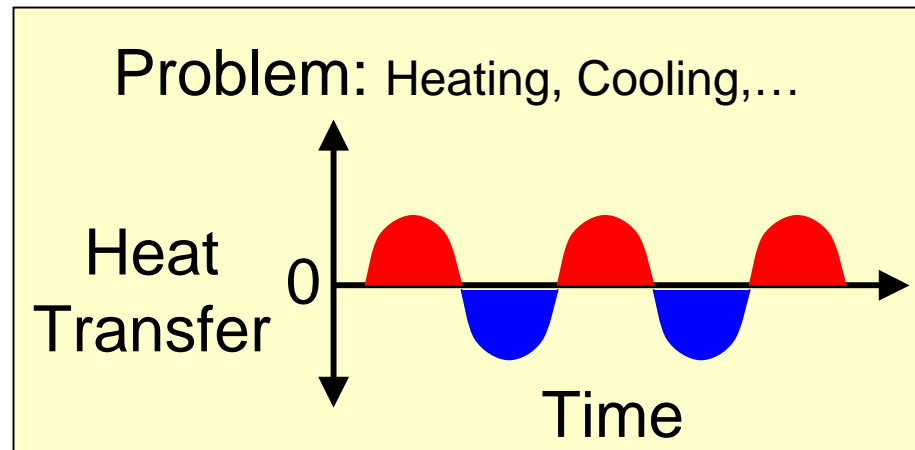
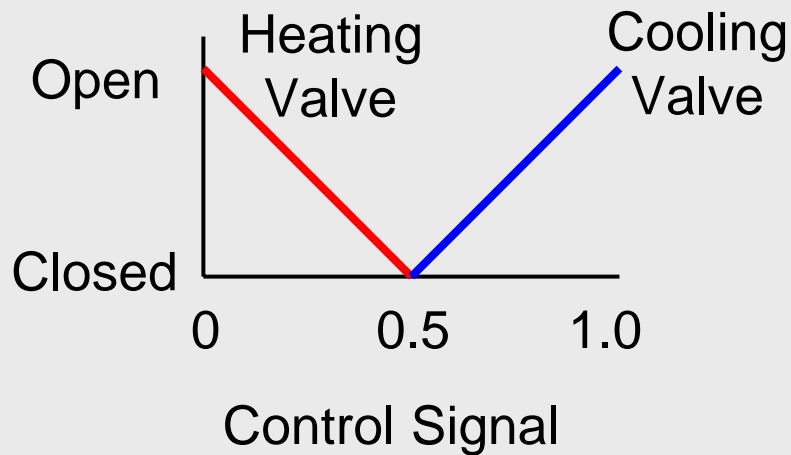
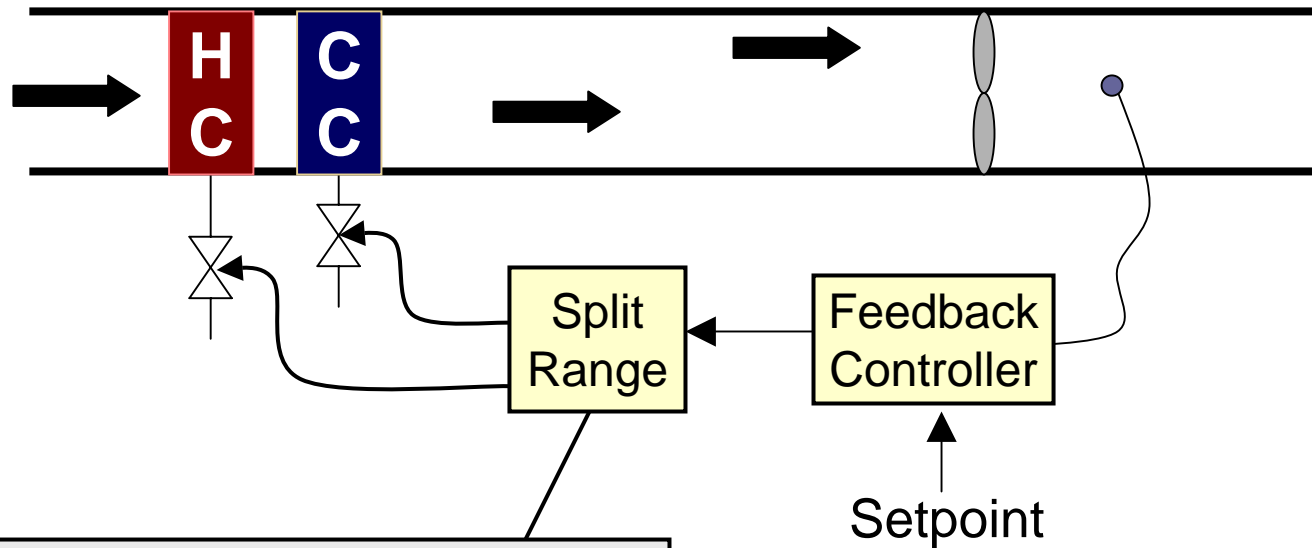


Simulation Results from Dr. John House

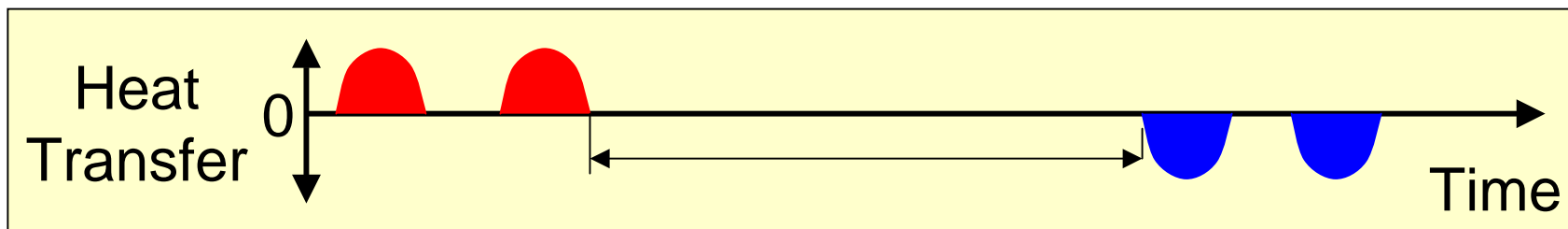
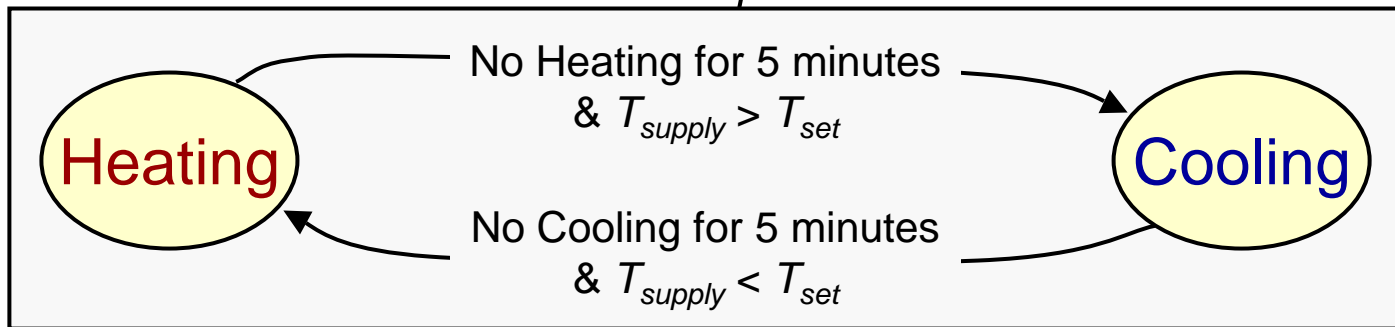
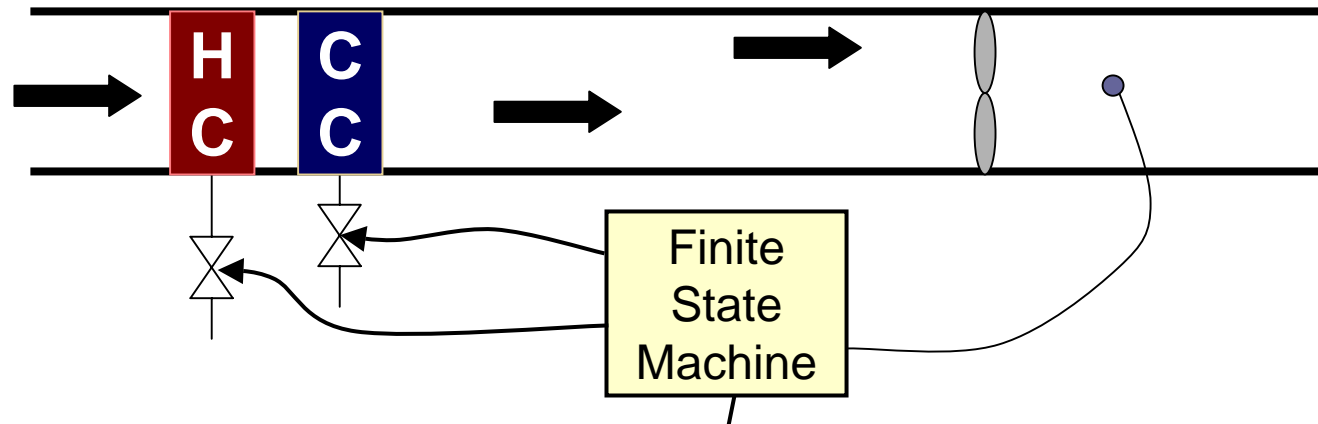
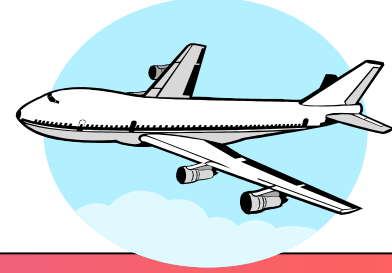
Heating valve 3% leakage
Heat. valve stuck 10% open
Cooling valve 3% leakage
Cool. valve stuck 20% open
Normal



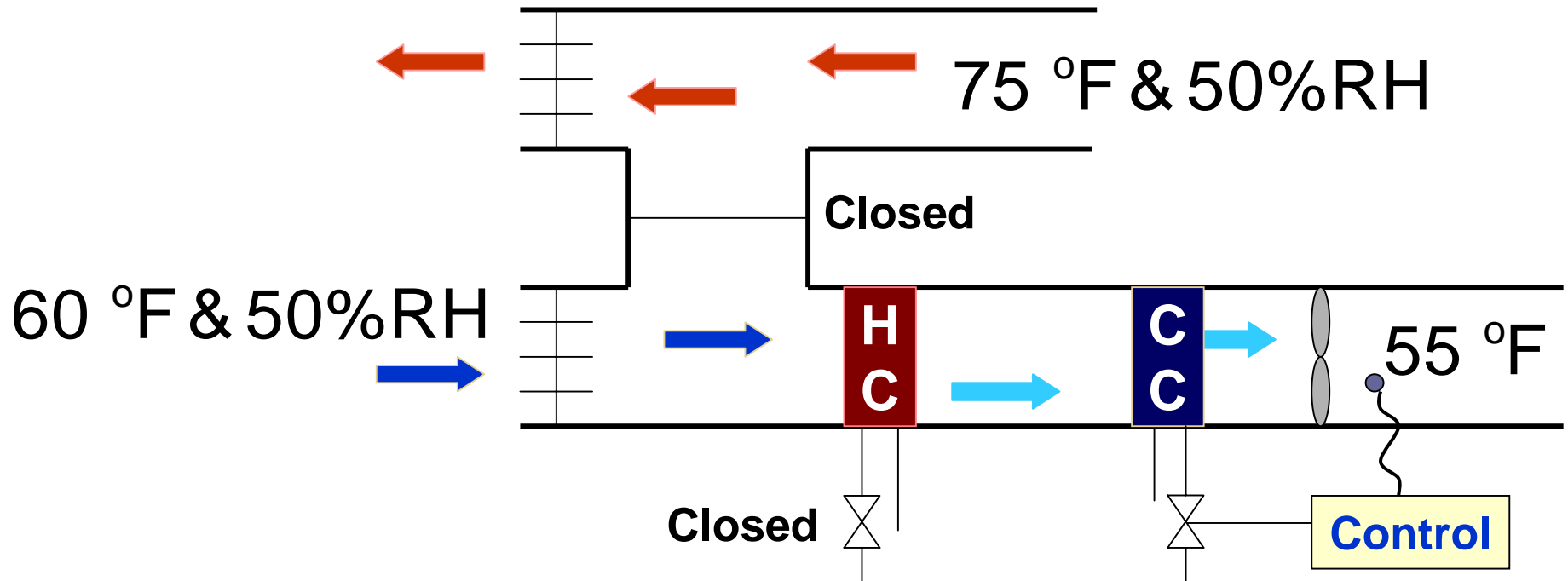
Split Range Control



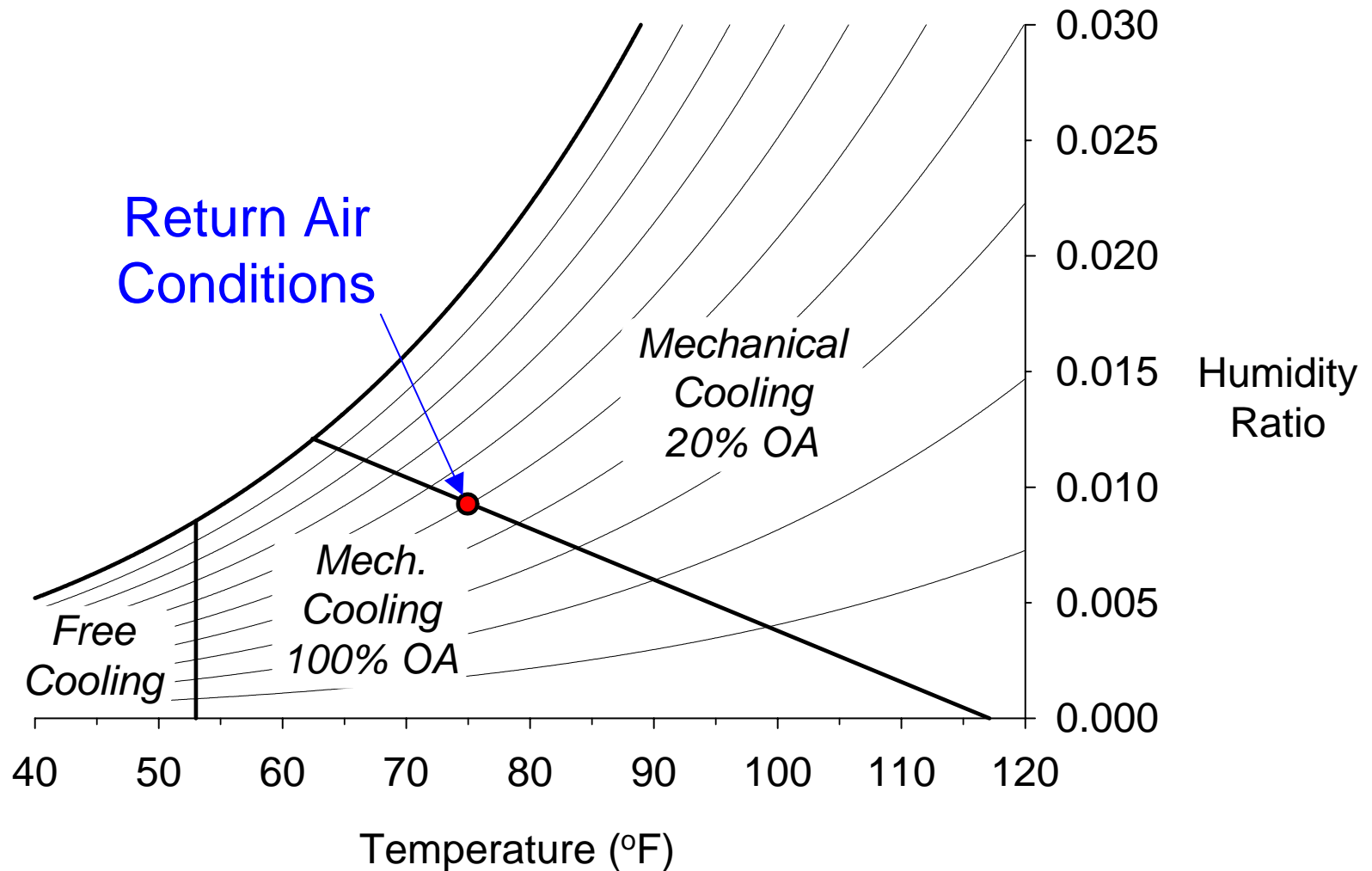
Finite State Machine



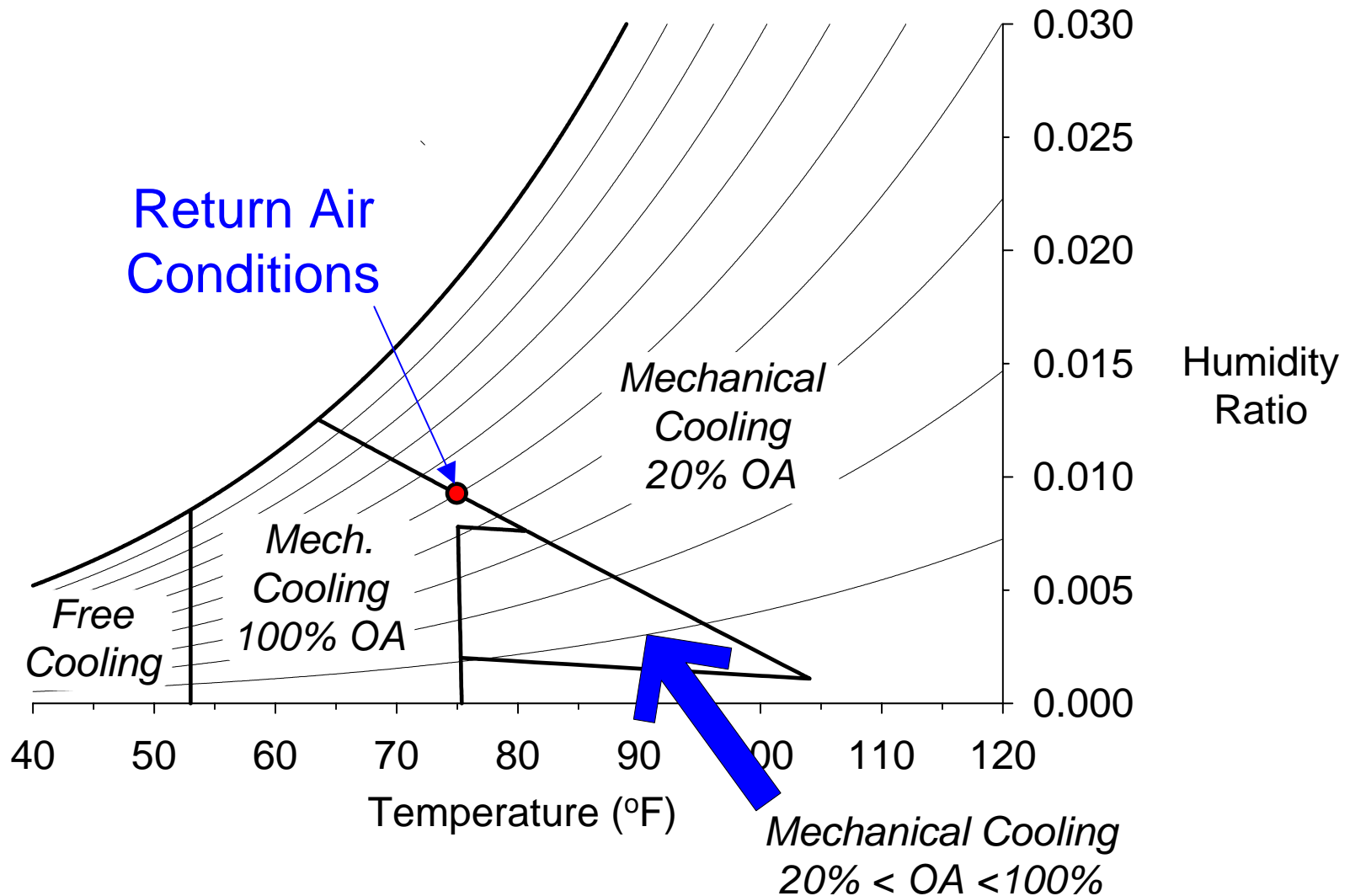
Air Side Economizer



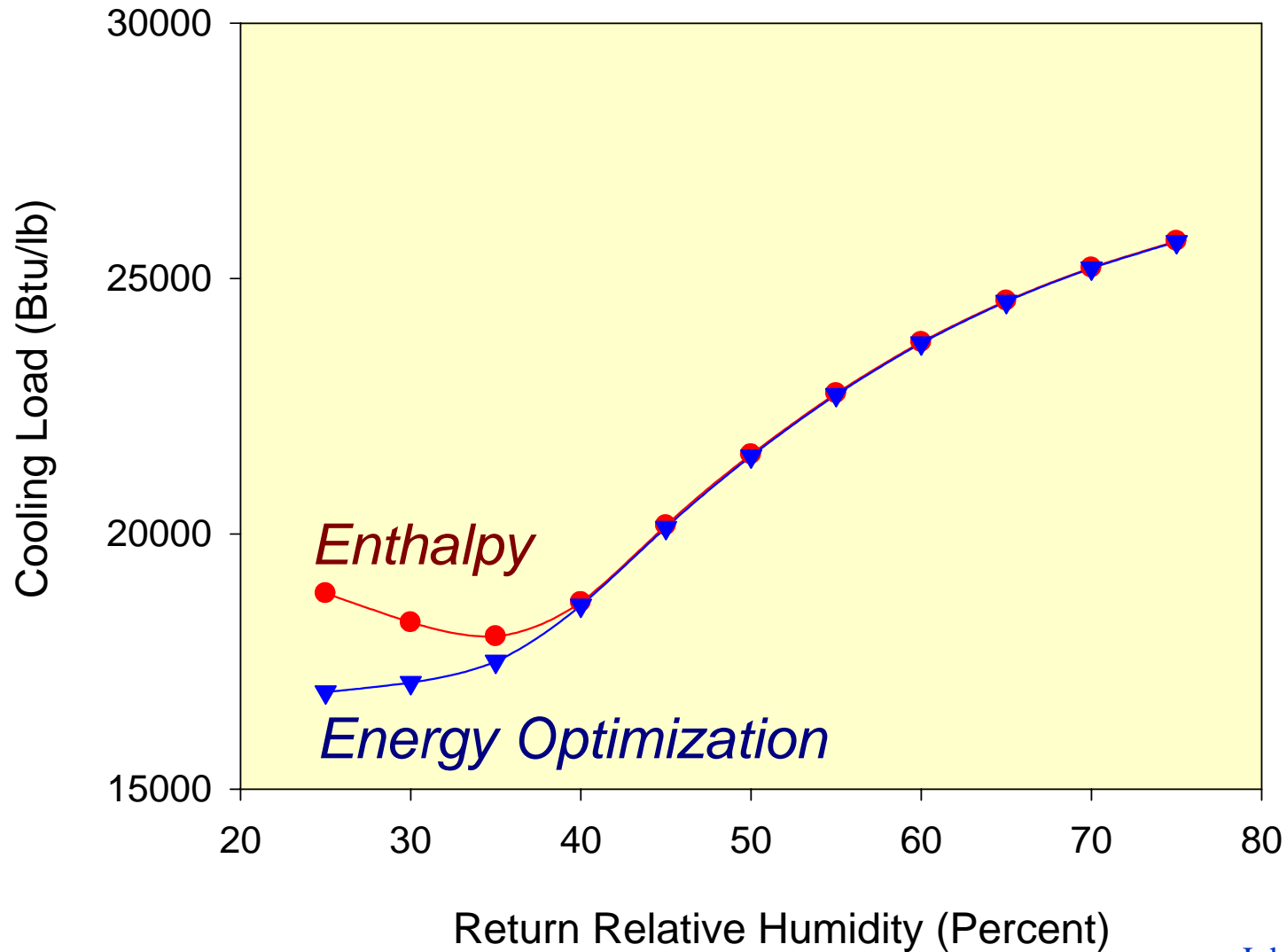
Enthalpy Economizer



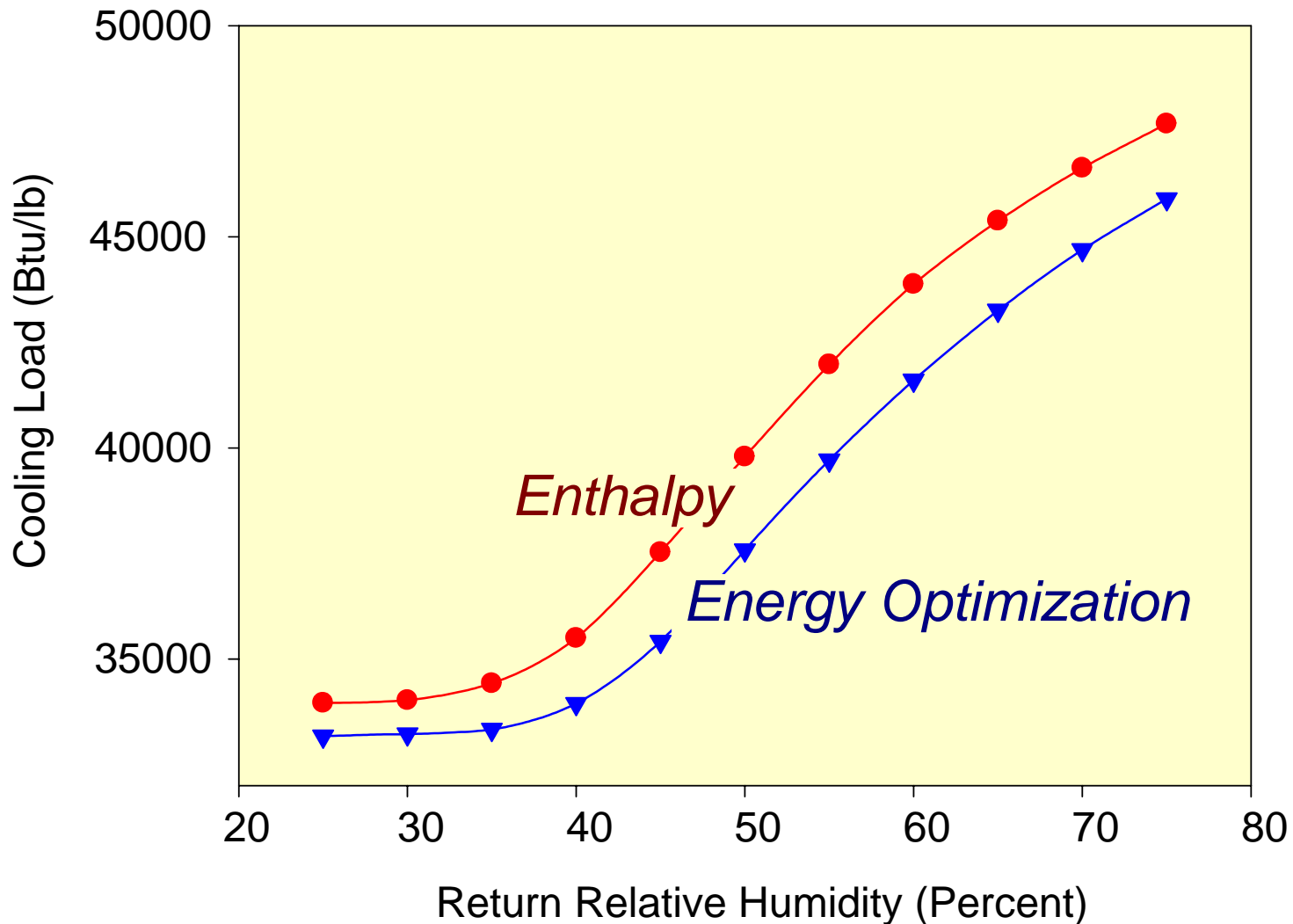
Energy Optimization Economizer



Simulation Results for New York



Simulation Results for Phoenix



Summary

- Tune feedback controllers
- Detect & fix faulty systems
- Stop fast switching: $H \Rightarrow C \Rightarrow H \Rightarrow C \Rightarrow H \Rightarrow C$
- Use energy optimization